S. A. 69

E & A

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 645

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. January 26, 1918

IMP.
4 - MAR 1918
ENTOM.

SOME REASONS FOR SPRAYING TO CONTROL INSECT AND MITE ENEMIES OF CITRUS TREES IN FLORIDA.

By W. W. YOTHERS,
Entomological Assistant, Tropical and Subtropical Fruit Insect Investigations.

CONTENTS.

	Page.		Page
Gradual adoption of spraying	1	Better grades of fruit bring better prices	13
Pests of importance	2	Spraying scheme for controlling citrus pests.	15
Injury to trees and fruit	2	Cost of spraying	16
The grading of fruit	3	Profits and benefits	17
Reduction in size caused by insects	8	Conclusion	18

GRADUAL ADOPTION OF SPRAYING.

Among Florida growers there have been developing during late years what may be called two schools for the control of citrus pests. One of these favors dependence upon natural enemies; the other, upon artificial methods, particularly spraying. The relative merits of these two general methods of control are not discussed here, since, as time passes, it becomes more and more evident that there is room for both under the widely varying conditions surrounding Florida groves. Enthusiastic supporters of control by natural agencies such as entomogenous fungi do not believe that the lowering of the grade and the reduction in the size of the fruits and of the yield, if any, are of sufficient importance to demand attention. Or perhaps the case may be stated more fairly by saying that they believe that it is more profitable to use no measures for the control of pests, contending that it pays better to grow the lower grades of fruit without treatment than the better grades with treatment.

It is interesting, however, and very encouraging to note the gradual adoption of a system of spraying for the improvement of orchard conditions by men who, only a few years before the Federal Bureau of Entomology began its demonstration work, believed in, and depended upon, natural agencies as the best all-round method of control. This change has come partly through a realization that fungi

parasitic on certain injurious insects, excellent as they are, have fallen short of what was expected of them, but more as a result of a spraying system developed by the writer, which, by taking all pests into consideration instead of merely the white flies, has proved the direct financial gain that will follow the intelligent application of spray mixtures. It is to certain advantages of this system of spraying that attention is called in this bulletin. Perhaps the best argument in favor of spraying is to be found in the difficulty experienced in securing the same grove for demonstration purposes two or three years in succession. Once the owner has seen with his own eyes the benefits resulting from careful and well-timed spraying, he refuses to accept the losses that he knows will come to him or his company through the setting aside of blocks of trees to serve as checks in community demonstration work.

PESTS OF IMPORTANCE.

Of the total damage caused by insects and mites to citrus in Florida, more than 95 per cent may be attributed to six species. In the order of their destructiveness, these are the citrus white fly,[1] the purple scale,[2] the rust mite,[3] the red scale,[4] the cloudy-winged white fly,[5] and the red spider.[6] There are several other pests of secondary importance, such as the woolly white fly,[7] the purple mite,[8] and the chaff scale.[9] The citrus white fly now infests nearly all the groves in the State. The purple scale is found in greater or less numbers on every citrus tree.

INJURY TO TREES AND FRUIT.

The presence of these pests on the trees and fruit produces blemishes which cause fruit to be placed in a much lower grade than would be the case if these blemishes were not present. While the excellent methods of washing the fruit remove nearly all the sooty mold which follows attacks of the white fly, usually some of it is left near the stem end. When this is present the fruit is placed in a grade lower than if it were absent. The presence of scale insects on the fruit lowers the grade, and, when these are abundant, makes the fruit practically unmarketable unless the scales are removed by hand washing. Perhaps the greatest cause for lowering the grade of fruit is the blemish following rust-mite injury. All these pests devitalize the trees, and this type of injury is much more important than the lowering of the grade of the fruit, because the yield is reduced. This

[1] *Dialeurodes citri* Ashmead.
[2] *Lepidosaphes beckii* Newman.
[3] *Eriophyes oleivorus* Ashmead.
[4] *Chrysomphalus aonidum* Linnæus.
[5] *Aleyrodes nubifera* Berger, now known as *Dialeurodes citrifolii* Morgan.
[6] *Tetranychus sexmaculatus* Riley.
[7] *Aleurothrixus howardi* Quaintance.
[8] *Tetranychus citri* McGregor.
[9] *Parlatoria pergandii* Comstock

devitalization is well known and admitted by the citrus growers, but few really appreciate the magnitude of this type of damage. Thousands of trees have been seen so injured by the purple scale that all the inside foliage and small limbs had been killed, and only a mere "shell" of foliage remained. In one small community in 1915 it was estimated that the damage amounted to $30,000. It cost four times as much to remove the dead wood resulting from insect attack as it would have cost to prevent the damage, and two crops of fruit were lost in addition. At least 75 per cent of the total damage could have been prevented for less than $2,000. Many citrus growers, realizing that this injury to the trees follows severe scale infestation, apply extra fertilizer so that the trees may have enough nourishment not only for the production of a good crop of fruit, but also to meet the demands made upon their vitality by the feeding scales. The belief is general that more fertilizer is required to get results in a grove heavily infested with scale insects and white flies than in one that is comparatively free from these pests.

To express the extent of this devitalizing effect in a statistical way or on a percentage basis is very difficult. In the two instances given below the damage caused by insect pests and mites is most strikingly shown. Although it is only proper to admit that these two cases represent extreme injury by pests, they indicate that the devitalizing effect which results in diminished yield is much greater, on an average, than most growers have thought possible.

In one instance a row of 16 trees was left unsprayed for three seasons, 1913, 1914, and 1915. The remainder of the grove was sprayed. The citrus white fly was making its first appearance in the grove. During the year 1913 there was little or no difference in the yields of the sprayed trees and the unsprayed check trees. In 1914 the unsprayed row had about 5 boxes of fruit, and the adjoining row of 16 sprayed trees about 60 boxes. All common species of fungi parasitic on the white fly and scale insects were present in great abundance. In 1915 the difference was not so great; the unsprayed row had about 20 boxes of fruit, and the adjoining sprayed row about 50 boxes.

As another instance, in a grapefruit grove at Safety Harbor 84 trees left without treatment during the summer of 1914 averaged two-thirds of a box per tree less than the trees adjoining which were sprayed. The reduction in the yield due to failure to spray was caused by the smaller size of the fruit resulting from rust-mite attack. There seems to be no evidence that the actual number of grapefruit on the unsprayed trees was less than on the sprayed trees. During the year 1915 the same trees received the same treatment as during 1914. The sprayed trees had at least a good half crop, or about four boxes per tree. The trees adjoining which were left

unsprayed during both years yielded only from one-half to one box per tree. This difference was so marked that all the laborers in the grove noticed it as early as August 1.

THE GRADING OF FRUIT.

PRESENT STATUS.

The percentage of first-grade fruit shipped out of Florida is not as great as it should be. To illustrate this point several tables have been prepared which give the percentages of the various grades shipped. These data have been obtained with difficulty. At first it was thought that information could be obtained from the growers. As a matter of fact the growers, as a class, do not know the percentage of the fruit in the different grades or the price received for the respective grades, for the reason that a large percentage of the citrus crop is sold on the tree, and shipped by those commission firms owning groves.

No information regarding the percentages of the various grades shipped could be obtained from the shipping companies. One important firm wrote that such large quantities of their fruit had been sold at so much per box, regardless of grade and size, that they were unable to give any information about grades and prices. The reports of the New York auction and the Florida Citrus Exchange were available.

The grading of fruit in Florida is in a most chaotic state. Certain grades marked "fancy" bring less money than third or fourth-grade brands. There are no standards for the various grades of fruit; the different grades vary as the season advances, and from year to year. It is very difficult to place each brand of fruit in its proper place. Attempt, however, was made to place it just as the shipper had intended. The Citrus Exchange key to the various brands was followed for all Exchange fruit. Wherever the word "fancy" occurred, this was placed in the first grade, "bright" in the second, and so on. This was strictly adhered to. The following table will explain this more fully:

First grade.	Second grade.	Third grade.	Fourth grade.	Fifth grade.
Fancy	Bright	Golden	Russet	Plain.
Stripes No. 1	Stripes B	Stripes R	Stripes Y	Big Cypress.
	Blue	Red	Yellow	Plain.
Deerfield F	Deerfield B	Deerfield G		
J R. W. Fancy	J. R. W. Choice	J. R. W. Golden		
	Balls of J	Florida Sunshine	Apex	

In order to arrive at the best estimate of the grades of fruit shipped from Florida at present it seemed best to adopt two fairly distinct methods to determine this for New York City and compare the results with those obtained from other sources.

By the first method the records of fruit sold on four days of each month in New York City were taken into consideration. Usually the days selected were the 3d, 10th, 20th, and 28th or 30th of each month, but other days might have been chosen just as well. The percentages of the various grades of fruit shipped, based upon the records for these representative days, are given in Table 1.

TABLE 1.—*Percentages of various grades of oranges and grapefruit shipped from Florida to New York City during the season of 1915–16.*

Month.	Oranges.					Grapefruit.				
	First grade.	Second grade.	Third grade.	Fourth grade.	Fifth grade.	First grade.	Second grade.	Third grade.	Fourth grade.	Fifth grade.
November	8.17	48.55	37.14	5.63	0.5	13.85	55.6	26.61	4.43	0.0
December	13.93	43.79	40.18	1.87	.25	20.02	33.68	39.55	6.73	.0
January	12.26	38.30	40.89	7.58	.95	9.44	46.72	35.31	8.7	.0
February	2.60	32.28	47.07	14.66	2.38	2.58	21.46	48.90	18.77	8.3
March	.25	25.89	52.64	17.39	3.81	.6	9.7	50.6	33.4	5.65
April	1.16	20.91	50.80	25.51	1.60	.0	17.0	58.57	20.36	4.33
Entire season.	6.68	34.82	45.07	11.80	1.62	6.92	29.86	44.74	15.24	3.25

The data in Table 1 are based upon the sale of 128,487 boxes of oranges and 31,479 boxes of grapefruit. In the second method for determining the percentage of fruit shipped to New York City in the various grades, the fruit was placed in only three grades instead of five. The fruit was classified by the same method used for Table 1, except that fruit marked "fancy" and "No. 1" was placed in the first grade, and all "plain," fourth and fifth grade fruit was left out. The results, based upon a study of the auction sales, including 400,806 boxes of oranges and 126,193 boxes of grapefruit, showed that the percentages of fruit in the three grades were 35.56, 44.33, and 20.10 for oranges, and 34.43, 45.61, and 20 for grapefruit.

These data and those of Table 1 show that the two methods for determining the grades shipped give about the same results. The better grades are shipped during November and December; the poorer grades, toward the close of the season. To a considerable extent this due to the demand of the holiday trade, which calls for the best fruit obtainable. This demand causes such a keen competition among packers that it is difficult for any but the better grades to find a market until after Christmas.

Since the fruit sold in New York City grades much higher than that sold in other markets, and, in fact, better than the average fruit of the State, the percentages of the different grades of fruit of this market and those of other markets must be compared, in order to arrive at a just conclusion as to the amount of fruit in the different grades shipped from the entire State. Such a comparison of grades sold in New York City and other markets, including Baltimore, Boston, Chicago, Cleveland, Philadelphia, Pittsburgh, and St. Louis, is made in Table 2.

TABLE 2.—*Percentages of various grades of oranges and grapefruit shipped from Florida to New York City and other markets during the season of 1915–16.*

Market.	Oranges.				Grapefruit.			
	First grade.	Second grade.	Third grade.	Total boxes.	First grade.	Second grade.	Third grade.	Total boxes.
New York City	35.56	44.33	20.10	868,541	34.43	45.61	20.00	272,621
Other markets	8.30	44.57	47.13	5,096,817	8.85	36.2	54.9	1,544,929
Totals and weighted percentages	12.39	44.53	43.08	5,965,358	12.67	37.62	49.69	1,817,550

Taking into consideration all sources of information regarding oranges and grapefruit shipped out of Florida, the conclusion is reached that for the purpose of this bulletin the percentages of fruit in the first, second, and third grades approximate 13, 41, and 46, respectively.

RAISING THE GRADE OF FRUIT BY SPRAYING.

Since by no means all Florida fruit is graded so well as that shipped to New York, the problem of raising the standard is an important one. Is it worth while? Will it pay? From the results of work in Florida it may be asserted confidently that it is worth while and that it will pay in a very large number of Florida groves. Table 3 gives the percentages of the grades of fruit shipped from the same grove during 1914, 1915, 1916 and during 1917, up to January 15. In 1914 the small amount of spraying done came too late to prevent blemishes caused by rust mites. In 1915 and 1917 the spraying was done at the proper time, but in 1916 the application was made a little too late to produce the best results. The data resulting from this experimental work are so striking that comment is unnecessary.

TABLE 3.—*Result of spraying upon the percentages of grapefruit in the various grades.*

Grade of fruit.	Year and treatment.			
	1914	1915	1916	1917
	Not sprayed.	Well sprayed.	Sprayed too late for best results.	Well sprayed.
First	2.7	34.3	15.8	33.7
Second	15.8	51.5	51.6	46.3
Third	50.0	10.2	17.3	14.2
Fourth	31.5	3.7	15.3	5.9

In a second grapefruit grove during the season of 1913–14, when no spraying was done, the percentages of fruit in the four grades ran 0, 13.8, 65.5, and 20.8, respectively. During the season of 1914–15

the fruit from the same trees after having been sprayed ran for the same grades 12.4, 73.1, 14.5 and 0 per cent, respectively. These data, presented by Mr. S. F. Poole before the Florida Horticultural Society,[1] show that spraying raised the percentages of fruit in the first two grades from about 14 to 85.5 per cent, while the same treatment lowered the percentage in the inferior third and fourth grades from 86.37 to 14.5 per cent and raised all fruit above the fourth grade.

In a third grove the grapefruit of the season of 1913–14, which had developed without protection by spraying, gave 0.6, 24, 59, and 16.4 per cent, respectively, in the four grades. The same trees, properly sprayed during 1914, yielded fruits during the 1914–15 season which graded for the same grades 27.4, 67.5, 5, and 0 per cent, respectively. In other words, spraying increased the amount of fruit in the first two grades from 24.6 to 94.9 per cent and reduced that in the lower grades from 75.4 to 5 per cent; increased the first grade from 0.6 to 27.4 per cent and reduced the fourth grade from 16.4 per cent to zero. The fruit in the two groves upon which data have been given were graded by the Winter Haven Citrus Growers' Association, and the spraying was done under the direction of Mr. S. F. Poole, of Winter Haven.

The foregoing data, secured in the same grove two or more years in succession, may raise the question whether the relative abundance of pests, or more favorable climatic conditions, may not have been an important factor in the better crops secured after spraying. Without discussing this point at length the data secured in various groves are given below:

Grove 1.—During 1913, 900 boxes of fruit picked from unsprayed orange trees in the community graded 32.6 per cent "bright" and 67.3 per cent "russet," while 914 boxes picked from a sprayed grove and apparently equally well cared for in other respects graded 90.4 per cent "bright" and 9.5 per cent "russet."

Grove 2.—In the Hill grove at Winter Haven, which was sprayed during 1914, the oranges shipped 60 per cent first, 35 per cent second, and 5 per cent third grade; and the grapefruit, 30 per cent first, 67 per cent second, and 3 per cent third grade. The general run of fruit grown in the same vicinity, upon trees in the same general state of culture except that many had not been sprayed at all and others sprayed only indifferently, and packed by the same packing house, may be taken as a fairly good index to the grade of fruit produced during the same season. This fruit shipped 10 per cent first, 62 per cent second, and 28 per cent third.

Grove 3.—In this grapefruit grove one block of trees was sprayed, a second block was left unsprayed after June, while a third block was kept as a check. Aside from spraying, the trees received practi-

[1] Florida Horticultural Society Report, 1915, pp. 130–132.

cally the same treatment as regards cultivation and fertilization. The fruit in the sprayed and unsprayed blocks grew on trees about 30 feet apart, or in adjoining rows, and was picked and packed on the same day. The carload of sprayed fruit shipped 87.4 per cent first and second and 12.6 per cent third and fourth grades; the unsprayed carload shipped no first, 3.3 per cent second, and 96.6 per cent third and fourth grades. A more striking example of what a maximum infestation of rust mites will do and the benefits derived from spraying can scarcely be conceived. The carload of fruit left unsprayed after June shipped 80.3 per cent first and second and 19.6 per cent third and fourth grades, thus indicating that if rust mites are controlled thoroughly until the 1st of July on grapefruit little damage will result. In other groves russeting has been observed in January and February.

Grove 4.—In this grapefruit grove, 1 mile distant from grove 3, sprayed and unsprayed fruit was grown during 1914 in adjoining rows. The fruit from the sprayed trees shipped 18.8, 58.1, 15.1, and 7.9 per cent, respectively, in the four grades known as "fancy," "bright," "russet," and "plain." The fruits from the unsprayed trees shipped 6.6, 43.6, 49.7 and 6 per cent, respectively, in the same four grades. The percentage of second grade, or "bright," fruit from the unsprayed trees is much greater than from unsprayed trees of grove 3, since the rust mites did not do so much damage in this grove. It will be noticed that 15.1 per cent of the fruit from sprayed trees was russeted, whereas 49.7 per cent was russeted on the unsprayed trees. In grove 4 the poorer results were due to the inefficiency of the spray solution.

The foregoing data, under the general head of grades of fruit, should convince any grower that it is possible to raise the grade of fruit by killing pests so that the fruit will grade at least 35 per cent first, 50 per cent second, and 15 per cent third, instead of the present average for the State, which is 13 per cent first, 41 per cent second, and 46 per cent third. Fruit usually will grow to a remarkable state of perfection on healthy trees if only the insects and mites are controlled. One grove, the fruit of which was packed by an association noted for its high-class work, produced 90 per cent "Blue," or A No. 1 grade. The writer has seen 120,000 boxes of grapefruit from sprayed trees that graded 60 per cent first and 25 per cent second.

REDUCTION IN SIZE CAUSED BY INSECTS.

Insects and mites not only lower the grades of the fruit by the blemishes they cause, but reduce the size to a considerable extent. In raising the grades of the fruit by spraying, large benefits are obtained in preventing the pests from reducing the size. In commercial grading it is very difficult to show the difference in size of

oranges that have been damaged by mites and those that have not, since in commercial houses all large, coarse fruits, as well as more or less fruit that is inferior, are always placed in the second or third grades with the "russets." This reduction in size is so great, however, that even in commercial grading the difference in size in the respective grades is considerable. Thus, in 941 boxes of oranges of the first grade, 7,111 boxes of the second, and 3,376 boxes of the third there were, on an average, 184.2, 197.9, and 200.4 oranges per box; a difference of 7 per cent in the number of fruits per box in the first and second grades, and of 8.8 per cent of those in the first and third grades.

The difference in size of the fruit of the various grades ranges from 4 to 14 per cent. In one community the general run of "bright" fruit (unaffected by mites) averaged 203.8 oranges per box, and the russeted fruit 222.2, or a difference of 9.28 per cent in favor of unaffected fruit. In another near-by grove that was sprayed the "bright" fruit averaged 214 and the "russets" 228 fruits per box, which is a difference of 6.6 per cent.

The number of grapefruit in 360 first, 970 second, and 279 third-grade boxes of fruit averaged 53.2, 57.5, and 51.9, respectively. In this instance the difference in number of fruits per box in the first and second grades is 8.2 per cent. Undoubtedly so many large, coarse fruits were placed in the third grade that these made the average number of fruits per box less than even in the first grade.

It is much better, however, to make comparison of fruit of the same variety from the same grove, and data are given here for this purpose. Table 4 shows the numbers of grapefruit per box for the various grades in a car of sprayed and of unsprayed fruit and of fruit which was not sprayed after June. These are the same carloads of fruit referred to on page 7, grove 3.

TABLE 4.—*Number of grapefruit per box from trees sprayed and unsprayed and from trees unsprayed after June.*

Grade.	Number of grapefruit per box.		
	Sprayed.	Not sprayed after June.	Not sprayed.
1. Fancy	42.2	46.6	0.0
2. Bright	43.6	49.7	48.4
3. Russet	45.2	52.3	49.3
4. Plain	38.8	43.2	46.1
General average	42.8	49.0	49.1

It will be seen that the sprayed fruit averaged 42.8 and the unsprayed fruit 49.1 fruits per box. This difference may not appear to be very great at first sight, but if the unsprayed fruit had been as

large as the sprayed, there would have been 344.1 boxes of fruit instead of 300, or a gain of 14.7 per cent. The "russet" grade is smaller in all cars than either the "fancy" or "bright." All large, coarse fruits, were packed in the "plain," although they might be classed as "brights." Table 4, although it contains the data given by a commercial concern, does not indicate as great a difference as really existed. On the unsprayed trees there were many fruits so small and of such poor quality that they were never sent through the packing house.

Grapefruit grown about 1 mile from that discussed in Table 4 was sprayed with a different material, soda-sulphur. The sprayed and unsprayed fruit was picked on the same day. The number of fruits per box from the sprayed trees averaged, for the same grades given in Table 4, 47.8, 51.7, 56, and 53.4 per box, respectively; from the unsprayed trees, 52.3, 56.7, 59.5, and 0, respectively. The "russet" fruit in both cases was much smaller than any of the other grades. Taken as a whole, the fruit from the sprayed and unsprayed trees averaged 51.5 and 57.8 fruits per box, respectively, which gives a percentage difference of 12.3 in the number of fruits in favor of spraying. In another instance grapefruit from sprayed trees averaged 50.2 fruits per box as compared with 57.8 fruits from unsprayed trees in adjoining rows; a difference of 15.2 per cent in favor of sprayed fruits.

The reduction in size following rust-mite attack accounts, to a certain extent, for the small number of boxes produced in 1911, when practically all the unsprayed citrus fruit was "russet," and about half was "black russet," or about two sizes smaller than it would have been had it not been affected by rust mites. One test shows that 66 sprayed fruits filled the same box as 99 unsprayed fruits picked from an adjoining row, or a difference of 33⅓ per cent. From orange trees sprayed with lime-sulphur, 1–25, April 22, 1911, 338 fruits averaged 3.29 inches in diameter. The skin of this fruit was smooth and the texture good. From unsprayed adjoining orange trees 1,234 fruits averaged 2.58 inches. It would require 112 of the former to fill the average orange box and 226 of the latter, or twice as many.

The reduction in size in also shown by the average weight of the fruit. In a miscellaneous lot of oranges, graded commercially, 575 "brights" weighed 241 pounds and 575 "russets" weighed 225¼ pounds, which made a difference of 6⅓ per cent. This fruit, of course, had been picked at the same time and from the same grove and the collection represented all the different sizes. The fruit had not received any spraying. In another lot, 75 "bright" grapefruit which had been sprayed thoroughly throughout the season weighed 99.75 pounds, and 75 fruits which had received no spraying throughout the year weighed 88 pounds, which makes a difference of 11.77 per cent.

The foregoing data show that the loss resulting from the reduction in size of the fruit is close to 12.5 per cent, or about one size. About half the citrus crop of Florida suffers this loss. The data also confirm the observations made on the size of "brights" and "russets" when packed. When fruit is graded in a packing house and then run through the sizer the full bin on the "bright" side is invariably one size larger than the full bin on the "russet" side. These facts also substantiate the statement of Mr. S. O. Chase, of Sanford, Fla., who figured out more than 25 years ago that the increase in size which results from spraying pays for the cost of spraying. They also confirm the statements of Mr. F. D. Waite, of Palmetto, and Mr. A. B. Harrington, of Winter Haven, that rust mites reduce the size about 12½ per cent.

The belief is general in Florida that "russet" fruit will ship better, or with less decay, than "bright" fruit. If this is the case it is possible that the supposedly superior shipping qualities of the "russet" fruit might outweigh any advantages which the "bright" fruit might possess. While the data given in the following paragraphs may not be entirely conclusive, they certainly show that bright fruit, which retains its natural "waxy" coating for protection, ships equally as well or better than "russet" fruit, or fruit that has been injured by rust mites to the extent of losing its normal protection.

Test 1: Grapefruit—On January 30, 24 brights and 24 russets were picked and placed in the laboratory. These were examined from time to time, and on April 7 46⅔ per cent of the bright fruit had decayed and 58⅓ per cent of the russets.

Test 2: Fifty-one grapefruit each, of brights and russets, were picked on the same day as the preceding and placed in the laboratory. On April 7, 49 per cent of the brights had decayed and 75½ per cent of the russets.

Test 3: Oranges—One box of bright oranges and one box of russet oranges, each containing 200 fruits, were purchased at the packing house on March 9. These fruits were picked from the same grove. On April 7 the bright oranges showed 48½ per cent decay and the russet oranges 59 per cent.

Test 4: One box of brights and one box of russets containing 160 oranges each were set aside March 9. On April 7, 29.3 per cent of the bright fruit had rotted and 30.6 per cent of the russets.

Test 5: One box each of brights and russets, containing 150 oranges each, were used on March 3. On April 7, 50 per cent of the bright fruit had decayed and 66 per cent of the russet.

Test 6: One-half box each of brights and russets were put under observation on March 3. On April 7, 54 per cent of the brights had rotted and 74 per cent of the russets.

In the spring of 1917 another series of experiments was conducted to determine the relative merits of bright and russet fruit with reference to their carrying qualities. Twelve lots of oranges, each containing an equal number of brights and russets, were picked and carefully selected so as to avoid any mechanical injuries. So far as possible, the brights and russets from each lot were taken from the same tree. Examinations were usually made every seven days. Table 5 gives the percentage of decay for each period of all the lots.

TABLE 5.—*Percentage of decay of "brights" and "russets."*

Number of days.	"Brights."				"Russets."			
	Number of sound fruits.	Number of decayed fruits.	Total number of decayed fruits.	Per cent decay.	Number of sound fruits.	Number of decayed fruits.	Total number of decayed fruits.	Per cent decay.
	95	0	0	0.0	95	0	0	0.0
5	94	1	1	1.05	95	0	0	.0
12	93	1	2	2.10	95	0	0	.0
19	89	4	6	6.31	87	8	8	8.42
26	79	10	16	16.84	78	9	17	17.90
33	71	8	24	25.26	56	22	39	41.05
40	60	11	35	36.8	40	16	55	57.90
47	59	1	36	37.89	31	9	64	67.36
54	50	9	45	47.36	12	19	83	87.36
61	34	4	49	51.57	11	1	84	88.42

The above experiment was terminated about 2½ months after it was started. At that time 27 of the bright fruits were sound, 25 of which were eaten, and only 3 of the russets were sound, none of which were edible. The 95 bright fruits had averaged 51 days and the 95 russet had averaged 36 days before developing decay. In 11 of the 12 lots the brights lasted longer than the russets. According to weight, the percentage of decay was 45.3 in the brights and 64.8 in the russets.

The rate of evaporation of the juices is also much greater in russet fruit than in bright. From January 30 to April 7, 1915, 24 bright grapefruit lost 4.7 per cent and 24 russet lost 13.6 per cent from evaporation. During the same time 51 bright grapefruit lost 5.9 per cent, and the 51 russet lost 9.5 per cent. One box of bright oranges lost 10.4 per cent, and another box of russets containing the same number of fruits lost 15 per cent. Another box of brights lost 14.8 per cent by evaporation and the box of russets lost 17.9 per cent. In one box of half brights and half russets the brights lost 17.4 per cent and the russets 21 per cent. In one box of brights the loss from evaporation was the same as that sustained by the russet box. In 8 of the 12 lots mentioned under "decay" (Table 5) the percentage of evaporation was greater from russet than from bright fruit and the total of the 12 lots showed the russets evaporated 23.12 per cent and the bright 22.68 per cent.

There seems to be an impression among consumers and retail dealers that russet fruit is a variety of citrus instead of being the result of the former presence of thousands of rust mites. The responsibility for this erroneous idea rests with the salesman. It is considered good salesmanship to sell what goods there are on hand and to convince the purchaser of the merits of the same. Since more than half the crop is russet, some explanation must be made to the consumer as to the quality of the fruit he purchases. The explanation that russet fruit is a variety fulfills all the requirements of good salesmanship. The necessity for this exercise of shrewd salesmanship, as well as its continuation, rests with the Florida citrus grower.

One also hears frequently in Florida that russet fruit is sweeter than bright. So far as is known, no analyses indicate that such is the case. Since the russet fruit is not sold before the holidays, it has ample opportunity fully to ripen, so no russet fruit is ever sour. In some tests made March 25, 1914, several russet and bright oranges were peeled so that they could not be told apart by the taster. These were given to a person to taste. In both cases where bright and russet fruit were compared, the person pronounced that the bright was the sweeter. On January 29, 1915, five men pronounced sprayed fruit sweeter and possessed of a greater refinement and delicacy of flavor than unsprayed fruit from adjoining rows.

BETTER GRADES OF FRUIT BRING BETTER PRICES.

Obviously it is useless to raise the grade of fruit if second and third grade fruit sell for as much as the first grade. There is no reason to spend money to make first-grade fruit unless the improved fruit brings a good yield on the investment required to produce it.

In order to show the difference in price received for different grades of fruit Tables 6 and 7 have been prepared. The data of Table 6 are based upon the returns from the 128,487 boxes of oranges and the 31,479 boxes of grapefruit, and these data are given in Table 1.

TABLE 6.—*Difference in the price received in the New York market for different grades of oranges and grapefruit during the season of 1915–16.*

Month.	Difference in price received between the grades of—									
	Oranges.					Grapefruit.				
	First and second grade.	Second and third grade.	Third and fourth grade.	Fourth and fifth grade.	Total difference.	First and second grade.	Second and third grade.	Third and fourth grade.	Fourth and fifth grade.	Total difference.
November	$0.39	$0.28	—$0.01	$0.39	$1.06	$0.66	$0.36	$0.29	$0.00	$1.30
December	.57	.08	.09	.05	.79	.55	.57	.26	.00	1.36
January	.23	.14	—.00	.37	.74	.37	.36	.34	.00	1.08
February	.73	.14	.14	.37	1.38	.68	.25	.25	.03	1.21
March	1.36	—.09	—.16	.49	1.59	2.22	.43	.47	.29	[1]1.20
April	.96	.14	.06	.67	1.82	.00	.18	.17	.25	.60

[1] Difference between second and fifth grades; first grade is unusual sale.

The dash (—) placed before the difference in price indicates that a lower grade sold for more than the next higher grade. This occurred several times among the grades of oranges, but not among those of grapefruit. The only explanation that can be offered for this irregularity is that the lower grades had the sizes desired by the trade at the particular time of the sale.

Table 7 shows the differences in price for the grades of 400,805 boxes of oranges and 126,193 boxes of grapefruit when these are divided into three instead of five grades.

TABLE 7.—*Differences in the price received in the New York market for different grades of oranges and grapefruit during the season of 1915–16.*

Month.	Difference in price received between the grades of—					
	Oranges.			Grapefruit.		
	First and second grades.	Second and third grades.	First and third grades.	First and second grades.	Second and third grades.	First and third grades.
November	$0.342	$0.044	$0.385	$0.517	$0.314	$0.831
December	.243	.136	.379	.369	.654	1.023
January	.221	.117	.338	.237	.362	.599
February	.168	.114	.282	.378	.325	.703
March	.099	.054	.045	.295	.569	.864
April	.226	.110	.336	.059	.279	.338

If the difference in price received for the first and third grades be added and the sum be divided by the number of months, an average difference of 30 cents in price received for the oranges and 72 cents for the grapefruit is obtained. In a miscellaneous lot of 5,427 boxes of fruit, the first grade averaged 48.8 cents more than did the second grade, and the second averaged 8.3 cents more than did the third grade.

Opportunity is seldom presented for comparing the price of sprayed and unsprayed fruit from the same grove. Through the cooperation of Mr. J. A. Stevens, of De Land, this was done with two carloads of grapefruit shipped in 1914 from sprayed and unsprayed trees, that were picked and packed on the same day and sold in the same market. The sprayed fruit sold for $1.94 per box; the unsprayed fruit for $1.69. These respective prices are disappointing. It had been anticipated that there would be at least a difference of 75 cents instead of 25 cents in favor of the sprayed fruit. The net profits due to spraying, however, were sufficient to pay one-fourth of the freight charges. Although the difference is slight, it is more than four times what it cost to spray the trees. The prices of the respective grades of the fruit could not be obtained.

In a grove about 1 mile distant from the grove previously mentioned 516 and 300 boxes of grapefruit, respectively, were picked from

sprayed and unsprayed trees in adjoining rows. It is not known whether all the fruit was sold in the same market. The sprayed fruit brought 98 cents per box, the unsprayed fruit 85 cents per box. The difference in price, though small, was twice the cost of spraying. Because of the vagaries of the market, due to the daily fluctuation in supply and demand, it can not be stated that the better grades will always bring the better price, yet the data presented leave no doubt that spraying raises the grade of the fruit and largely overcomes the devitalized effect caused by insects, and that, other things being equal, the better grades bring better prices.

SPRAYING SCHEME FOR CONTROLLING CITRUS PESTS.

As a general proposition the time to spray for the control of all pests of citrus trees is when they are present in such numbers that, if left to reproduce without artificial hindrance, they would soon become injurious. In other words the pests should be killed before they can do much damage to either the tree or the fruit. The pests should always be kept in such a state of repression that they can do little or no damage. In case the various pests of citrus are permitted to become so abundant as to cause injury, the profits which may be expected from artificial treatment, such as spraying with an insecticide, are, to a certain extent, lost. Fortunately the life history and habits of nearly all citrus pests are such that good results can be obtained at any time of the year when the spray is applied. Nevertheless there are times when spraying is more opportune than at others. These periods come when the largest number of the insects are very young, for then they are killed most easily.

The following spray scheme has been used very extensively for four summers in Florida and generally has given satisfactory results. It must be admitted, however, that no hard and fast scheme can be recommended, and that to a large extent the number of sprayings depends on the thoroughness of the work.

I. *Paraffin-oil emulsion; Government formula, 1–66 or 1 per cent of oil. May.*—The main object of spraying at this time is to kill white flies, scale insects, and, to a large extent, rust mites. This treatment, however, must not be relied upon to control rust mites. The spraying should be done after the adults of the first brood of white flies have disappeared and before the appearance of those of the second brood. The fruit should be an inch or more in diameter. Since this treatment is given before the beginning of the rainy season, it does not interfere with the work of the beneficial fungi in reducing those insects not killed by the spray.

II. *Lime-sulphur solution, 32° Baumé, 1–50 to 1–75. June to July.*—The main object of this treatment is to kill rust mites, and the

correct time for its application varies with the appearance of the maximum number of the rust mites. It should be applied before the mites get very abundant and before any russeting appears. It will also kill some scales and white flies, but is not of great value for that purpose.

III. *Paraffin-oil emulsion; Government formula 1–66, or 1 per cent of oil. August 25 to October 31.*—This is the second spraying for white flies and scale insects. The object of spraying at this time is to kill the white-fly larvæ which are the progeny of the third and last brood. It is this brood that causes nearly all the damage from the white flies, and the earlier they are killed the better it is for the trees. This spraying also will remove the sooty mold from the trees and a sufficient amount from the fruit to permit the fruit to be colored up by the sun. *Soda-sulphur, 1–50*, may be added to this spraying to increase its effectiveness in killing rust mites.

IV. *Lime-sulphur solution, 32° Baumé, 1–50 to 1–75. November or December.*—The object of this spraying is to kill rust mites, and it may or may not be necessary, depending on the abundance of the mites.

It may be necessary to spray for rust mites before Treatment I is given. This is especially the case with grapefruit in the more southern counties. In case the red spider becomes abundant enough to cause injury, an application of lime-sulphur solution should be given. In case of heavy scale-insect infestation it may be necessary to spray three times with the oil sprays, in which case the treatment can be given in midsummer or in winter. If the red scale is very abundant, two sprayings with the oil emulsions should be given at intervals of about a month.

The paraffin-oil emulsion may be made according to directions given in Circular No. 168, Bureau of Entomology.

In addition to the foregoing there are three highly satisfactory miscible-oil sprays on the market in Florida.

The soda-sulphur solution is made according to the standard formula: 30 pounds of sulphur, 20 pounds of caustic soda, and 20 gallons of water. This tests about 16° Baumé and may be used 1–40 instead of lime-sulphur solution, but it is not so effective in controlling rust mites. It has an advantage over lime-sulphur solution in that it mixes readily with the oil emulsions.[1]

COST OF SPRAYING.

The cost of spraying depends upon many different factors, such as the size of the trees, nearness to water, convenience of operation, type of spraying outfit employed, insecticide used, and character of

[1]For directions for making lime-sulphur solution see Farmers' Bulletin 908.

the labor. No grower should expect to spray a bearing tree for less than 3 cents for each application. It would be better to place the minimum at 4 cents. It should not require more than 10 cents to spray the largest trees in the State if any considerable number are present in one grove. An average cost per tree should not exceed 5 to 6 cents. If one figures the cost per box, a minimum would be 1 cent per application for oil spray and somewhat less for lime-sulphur. A maximum would be 1½ cents for either insecticide. An expenditure of more than 6 cents per box for the entire year should be unnecessary.

PROFITS AND BENEFITS.

It is impossible to express accurately the percentage of profit to be expected from spraying to control pests on citrus. The same condition applies to cultural and other grove operations in Florida. The data at hand are sufficiently accurate, however, to be worth presenting.

It has been shown that the better grades bring more money than the lower, yet it would be fallacious to assume that if the entire crop were of a high grade the grower would receive correspondingly higher prices. The trade will consume only so much high-grade fruit. It is reasonably certain, however, that the Florida crop has not yet reached the high standard where it would be no longer profitable to produce more high-grade fruit.

At present 13 per cent first, 41 per cent second, and 46 per cent third grade oranges are shipped from the State, and it is possible and practicable to raise this standard to 35, 50, and 15 per cent for first, second, and third grades, respectively. It is assumed that the trade would handle fruit of this quality. Thus, the first grade is increased 22 per cent and the second 9 per cent. If 7,600,000 boxes are taken as the basis for the crop of 1915–16, there would be 1,273,987 boxes more in the first grade if spraying were done. These would sell, according to Table 7 (oranges) for 21.6 cents[1] more per box, or an increase of $275,181. There would also be 9 per cent more second grade, or 521,177 boxes. These would sell for 9.6 cents more, or an increase of $50,033.

The percentage of the various grades of grapefruit was not very different from that of the oranges, so 13, 41, and 46 per cent may be used to represent the first, second, and third grades of grapefruit, respectively. The standard for grapefruit also can be raised to grade 35, 50, and 15 per cent. There would then be 22 per cent, or 399,685 boxes, which would sell for 30.9 cents per box more, an increase of $123,559. There would be 9 per cent, or 163,508 boxes, which would

[1] New York City prices. Other prices could not be obtained.

sell, according to Table 7 (grapefruit), for 41.7 cents more per box, or an increase of $61,182.

The total increase in value by raising the grade would be $509,955 for the entire crop of oranges and grapefruit.

Elsewhere in this bulletin it has been shown that "russet" fruit is of about one size, or about 12.5 per cent smaller than normal fruit. If it is estimated that one-half of the crop is "russet" there would be a reduction of 475,000 boxes, which, valued at $1, would produce a loss of $475,000. This is extremely conservative. As a matter of fact, 100,000 boxes of fruit in Florida are thrown away because the fruit is too small!

In regard to the reduction in yield caused by the devitalization of the trees, it is very conservative to estimate this at 10 per cent, or 760,000 boxes. In reality it is probably 20 to 25 per cent, and many sprayed groves prove this to be true, but for this estimate it is placed at 10 per cent. This amount of fruit is valued at $760,000.

This would make a total of $1,744,955 as a minimum estimate for the increase that could be expected from spraying the entire crop. The cost of spraying groves producing 7,600,000 boxes would be not more than 6 cents per box, or $456,000. This would be a net gain of $1,288,955 in the value of the crop produced. This gain could be divided in half and still a handsome profit would follow spraying.

In addition to the direct profit, there is the satisfaction, which every enthusiastic orange grower must feel, in maintaining healthy trees and producing high-grade fruit.

CONCLUSION.

Of the total damage caused by insects and mites to citrus in Florida, more than 95 per cent may be attributed to six species. These, in the order of their destructiveness, are the citrus white fly, the purple scale, the rust mite, the red scale, the cloudy-winged white fly, and the red spider.

Aside from the satisfaction of growing fine fruit and owning healthy trees, it is estimated from the data reported in this bulletin that had the 1915–16 crop of oranges and grapefruit been sprayed according to the schedule recommended, the growers of Florida would have increased their net returns by $1,288,955.

There is no reason why the standard percentage of fruit in the higher grades can not be raised so that the percentage in the first, second, and third grades will be 35, 50, and 15 instead of, as at present, 13, 41, and 46. In one of several instances given, spraying increased the amount of fruit in the first and second grades from 24.6 to 94.9 per cent, and reduced that in the third and fourth from 75.4

of Agriculture 1918-03-05.

to 5 per cent; increased the amount in the first grade from 0.6 to 27.4 per cent, and reduced that in the fourth from 16.4 per cent to zero.

The better prices which, in most instances, can be obtained for the better grades of fruit fully warrant the adoption of a spray system that improves the grade and the amount of fruit produced. The data presented leave no doubt as to the practicability of making such improvement in the Florida citrus crop if the grower will adhere to the spray schedule outlined.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY
△

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917